

CHARACTERIZATION OF FINE PARTICULATE MATTER IN OHIO

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ABSTRACT

As a result of recent changes in the air quality standards for particulate matter, an exhaustive study was undertaken to measure PM_{2.5} in Ohio. The ambient results reported here are from an ongoing field experiment in Ohio that began in January of 1999. The ambient monitoring is part of a comprehensive health based study evaluating the impact of air pollution on pediatric health in Ohio. This is among the first of its kind in Ohio, with continuous ambient air monitoring at several sites to characterize fine particulate matter concentrations within the region using Tapered Elemental Oscillating Microbalance (TEOM) samplers. Two locations in Columbus, Ohio were chosen, one in the urban corridor and the other in a suburban location. A third location in rural Athens, Ohio was also established. In addition to the continuous monitors, filtered samples were gathered for chemical analysis of the particulate matter using an x-ray fluorescence spectrometer and an ion-chromatography unit. A spatial homogeneity in the mass concentration time-series data was noted. Sulfate was the largest component of the PM_{2.5} comprising approximately 40% of the total mass

INTRODUCTION

In 1997, the United States Environmental Protection Agency (EPA) implemented new National Ambient Air Quality Standards (NAAQSs) for ozone (O₃) and particulate matter (PM). These standards were based on multi-year scientific assessments that linked health effects to present air pollution levels. The standards, which tighten the requirements for attainment, will have significant economic and social impact for Ohio. For example, under the PM_{2.5} standard, estimates have indicated that 26 counties in Ohio will be in non-attainment. In comparison, one county in Ohio does not currently meet the NAAQSs for PM₁₀.

There is limited data on PM_{2.5} concentrations and its constituents in Ohio. The few historical studies (1,2,3) that have been conducted were health-based studies centered on areas with historically high levels of air pollutants, such as Steubenville, Ohio. This paper presents findings from an ambient PM_{2.5} monitoring campaign that is part of a large on-going health based study in Columbus and Athens, Ohio.

The field experiment, which began in February of 1999, consists of three longitudinal studies involving a rural location (Athens, Ohio), and two urban settings (both within Columbus, Ohio). Two contrasting sites in Columbus were established -- one urban (south central side of Columbus), and one suburban (New Albany, OH). Columbus, like numerous other metropolitan areas in the state and across the nation, has historically met the NAAQS for ozone and PM₁₀ but has the potential for non-attainment under the new PM_{2.5} and O₃ standards. The rural site (Athens Ohio) was chosen due to its proximity to the background site established by Ohio EPA for PM₁₀ and recently PM_{2.5}. Athens is also being utilized as a background site for the Upper Ohio River Project (4), a comprehensive PM fine and precursor gas monitoring program centered in Pittsburgh that was initiated in early 1999.

MATERIALS AND METHODS

Data is collected simultaneously from three monitoring sites that typify urban, rural, and a downwind suburban location. These sites will aid in the characterization of fine particulate spatially and temporally. PM_{2.5} measurements are obtained with TEOM series 1400a monitors manufactured by Ruprecht and Patashnick Co. The TEOM is a real time gravimetric instrument that draws ambient air through a filter at a constant flow rate and measures PM concentrations continuously. The TEOMs are equipped with automatic cartridge collection units (ACU) fitted with 47 mm filter packs. Samples are collected on Teflon filters. At each site, seven hour (8:30 a.m. -3:30 p.m.) samples are collected Monday thru Friday. The outdoor monitoring regime is tied to simultaneous indoor and personal

monitoring conducted as part of the health based study. Particle mass is determined using an electronic microbalance. The Teflon filters are equilibrated prior to weighing under controlled conditions (22.5 ± 2.5 C and $35 \pm 5\%$ relative humidity). The filters are then subjected to elemental analysis by energy dispersive x-ray fluorescence (XRF). This non-destructive technique is capable of identifying and quantifying elements in the periodic table from atomic number 9 (fluorine) to atomic number 92 (uranium). The samples are then analyzed for water soluble ions by ion chromatography. The water soluble species measured include five anions (fluoride, chloride, nitrate, phosphate, and sulfate) and five cations (sodium, ammonium, potassium, magnesium, and calcium). Meteorological parameters such as temperature, wind speed, wind direction, relative humidity, and precipitation are also measured hourly at each site.

RESULTS/DISCUSSION

The first phase of this project is currently being analyzed. Detailed statistical analysis will be presented at the Particulate Matter and Fossil-Fuel Combustion Symposium - 2000 American Chemical Society Meeting in San Francisco, March 26-31, 2000. Site characterization of the $PM_{2.5}$ and its constituents both temporally and spatially will be evaluated. In addition, the influences of meteorological parameters on total mass and chemical constituents of the $PM_{2.5}$ will be examined.

Daily averaged TEOM data for February through the middle of May are contrasted in Figure 1 for the three sites -- New Albany (suburban, Columbus), Koebel (central urban, Columbus) and East (rural, Athens). What is striking about the preliminary analysis is the uniformity in the data between the sites. New Albany and East (which are approximately 80 miles apart) show very similar temporal profiles over the entire sampling period. Koebel (central urban location) which experienced higher concentrations, potentially influenced by local sources, also had similar temporal patterns. This uniformity is further demonstrated in Figure 2 which presents the diurnal changes in $PM_{2.5}$ for June 2nd thru the 6th. Again all three sites show similar patterns in the concentration profile. Table 1 lists the results of the daily averaged $PM_{2.5}$ concentrations for February and March. As expected Koebel (urban) had a slightly higher average concentration followed by New Albany (suburban) and East (rural). Preliminary analysis by ion chromatography on the filter samples for February and March at East indicates that SO_4^{2-} is the primary water-soluble fraction, comprising on average 40% of the total $PM_{2.5}$ mass.

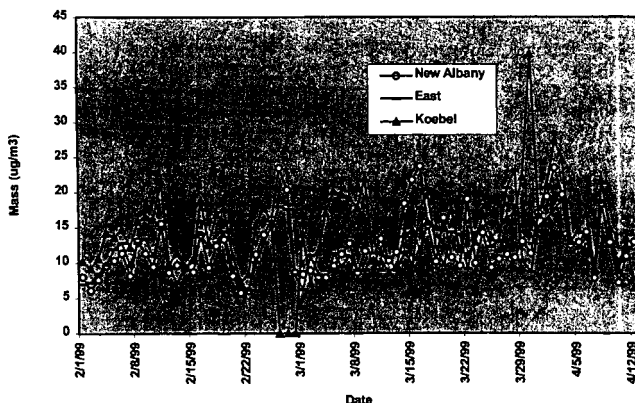


FIGURE 1. Daily average variations in $PM_{2.5}$ concentrations (TEOM) for Koebel (urban Columbus), New Albany (suburban Columbus), and Athens (rural).

CONCLUSIONS

Detailed analysis of the data is currently ongoing. However, preliminary review of the data indicates spatial homogeneity in the $PM_{2.5}$ concentration. This uniformity is experienced in

the daily average concentrations and in the diurnal patterns experienced at each site. SO_4^{2-} was found to comprise 40% of the $\text{PM}_{2.5}$ concentration at the rural site.

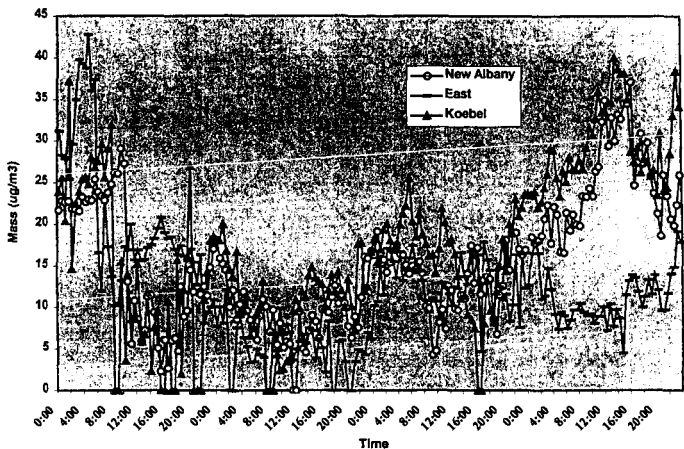


FIGURE 2. 30-minute average variations in $\text{PM}_{2.5}$ concentrations: June 2-6, 1999 for Koebel (urban Columbus), New Albany (suburban Columbus), and Athens (rural).

Table 1. Summary of the Daily Averaged $\text{PM}_{2.5}$ and Sulfate Concentrations for February and March 1999*

Site	Total Mass mean \pm SD	SO_4^{2-} mean \pm SD
New Albany (suburban)	11.8 \pm 4.1	
Koebel (urban)	14.7 \pm 5.1	
East (rural)	11.6 \pm 3.6	4.7 \pm 2.2

* Filter samples are collected five days per week (Monday thru Friday). Concentrations expressed as $\mu\text{g}/\text{m}^3$.

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